

FIELD OF INVENTION

The present invention relates to generally to systems, apparatus, devices and methods for interacting with computers and in particular to a system and method for
5 providing to a user printed information.

The invention has been developed primarily to allow a large number of distributed users to interact with networked information via printed matter and optical sensors, thereby to obtain interactive printed matter on demand via high-speed networked color printers. Although the invention will largely be described herein with reference to this use, it will be appreciated that the invention is not limited to use in this field.

CO-PENDING APPLICATIONS

57 > Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention simultaneously with the present application:

15 NPA014US, NPA015US, NPA022US, NPA023US, NPA024US, NPA025US,
NPA026US, NPA037US, NPA038US, NPA041US, NPA047US, NPA049US,
NPA050US, NPA051US, NPA052US, NPA053US, NPA063US, NPA065US,
NPA067US, NPA068US, NPA069US, NPA071US, NPA072US, NPB003US,
20 NPB004US, NPB005US, NPP019US, PEC04US, PEC05US, PEC06US,
PEC07US

The disclosures of these co-pending applications are incorporated herein by cross-reference. Each application is temporarily identified by its docket number. This will be replaced by the corresponding USSN when available.

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention on 23 May 2000:

30	NPA001US,	NPA002US,	NPA004US,	NPA005US,	NPA006US,	NPA007US,
	NPA008US,	NPA009US,	NPA010US,	NPA012US,	NPA016US,	NPA017US,
	NPA018US,	NPA019US,	NPA020US,	NPA021US,	NPA030US,	NPA035US,
	NPA048US,	NPA075US,	NPB001US,	NPB002US,	NPK002US,	NPK003US,
	NPK004US,	NPK005US,	NPM001US,	NPM002US,	NPM003US,	NPM004US,
	NPN001US,	NPP001US,	NPP003US,	NPP005US,	NPP006US,	NPP007US,
35	NPP008US,	NPP016US,	NPP017US,	NPP018US,	NPS001US,	NPS003US,

NPB003US

The disclosures of these co-pending applications are incorporated herein by cross-reference. Each application is temporarily identified by its docket number. This will be replaced by the corresponding USSN when available.

BACKGROUND

Paper is widely used to display and record information. Printed information is easier to read than information displayed on a computer screen. Hand-drawing and handwriting afford greater richness of expression than input via a computer keyboard and mouse. Moreover, paper doesn't run on batteries, can be read in bright light, more robustly accepts coffee spills, and is portable and disposable.

Online publication has many advantages over traditional paper-based publication. From a consumer's point of view, information is available on demand, information can be navigated via hypertext links, searched and automatically personalized.

From the publisher's point of view, the costs of printing and physical distribution are eliminated, and the publication becomes more attractive to the advertisers who pay for it because it can be targeted to specific demographics and linked to product sites.

Online publication also has disadvantages. Computer screens are inferior to paper. At the same quality as a magazine page, an SVGA computer screen displays only about a fifth as much information. Both CRTs and LCDs have brightness and contrast problems, particularly when ambient light is strong, while ink on paper, being reflective rather than emissive, is both bright and sharp in ambient light.

SUMMARY OF INVENTION

It is an object of the present invention, at least in the preferred embodiments, to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

According to a first aspect of the invention there is provided a system for providing printed information to a user that is obtained from a first server means of a first party, the system including:

a user printer module being provided by a second party for interfacing the user with the first server means, the module being responsive to the user requesting first information from the first server means for generating a first printed media that displays the first information;

identifier means of a third party for providing the first printed media with an identifier such that designation of the identifier by the user results in the module communicating second information to the first server means or to a second server means of a fourth party; and

- 5 account means for providing payments to the third party and for receiving payments from one or more of the first party, the second party and the fourth party.

Preferably, the system includes calculation means which is responsive to the identifier means and/or the module for determining the quantum of the payments. More preferably, the system includes a plurality of modules provided to respective users,
10 wherein the calculation means is responsive to the number of first media printed by the modules for determining the quantum of the payment received from one or more of the first, second and fourth parties.

Preferably also, the calculation means is responsive to the number of occurrences of second information being sent to the first server means or the second
15 server means for determining the quantum of the payment from the first party or the fourth party respectively. Even more preferably, the first and the fourth parties are respective on-line publishers and the payments they make are one or a combination of: a fixed amount for a predetermined period; proportional to the number of their advertisements that are printed. Preferably also, the publishers gain payment from
20 respective advertisers for the advertisements that are placed.

In a preferred form, the system, upon receipt of the second information by the first server means or the second server means, generates a second printed media that displays third information which is derived from the first party or the fourth party respectively. More preferably, the second printed media is generated by the module.

- 25 In a preferred form the identifier is printed on the respective printed media. More preferably, the identifier is printed on the respective printed media by one of the modules.

According to a second aspect of the invention there is provided a system for providing printed information to a user that is obtained from a first server of a first party,
30 the system including:

5 a database of a third party for providing an identifier which is included with the first printed media such that designation of the identifier by the user results in the module communicating second information to the first server or to a second server of a fourth party; and

10 payments from one or more of the first party, the second party and the fourth party.

Preferred and other embodiments of the invention will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

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Figure 15 is a schematic block diagram of duplexed print engine controllers and Memjet™ printheads associated with the printer controller shown in Figure 14;

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Figure 18 is a perspective view of a small part of an array of Memjet™ printing elements;

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Figure 21 is a schematic view of a registration server class diagram;

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Figure 24 is a schematic view of a printer class diagram;

Figure 26 is a schematic view of an application class diagram;

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Figure 29 is a schematic view of a document and page ownership class diagram;

Figure 31 is a schematic view of a static element specialization class diagram;

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Figure 34 is a schematic view of a hyperlinked group class diagram;

Figure 35 is a schematic view of a form class diagram;

Figure 36 is a schematic view of a digital ink class diagram;

Figure 37 is a schematic view of a field element specialization class diagram;

Figure 38 is a schematic view of a checkbox field class diagram;

5 Figure 39 is a schematic view of a text field class diagram;

Figure 40 is a schematic view of a signature field class diagram;

Figure 41 is a flowchart of an input processing algorithm;

Figure 41a is a detailed flowchart of one step of the flowchart of Figure 41;

Figure 42 is a schematic view of a subscription delivery protocol;

10 Figure 43 is a schematic view of a hyperlink request class diagram;

Figure 44 is a schematic view of a hyperlink activation protocol;

Figure 45 is a schematic view of a form submission protocol;

Figure 46 is a schematic view of a commission payment protocol;

Figure 47 is a schematic view of an advertising fee payment protocol;

15 Figure 48 is a schematic view of a click-through fee payment protocol;

Figure 49 is a schematic view of a sales commission payment protocol;

Figure 50 is a schematic view of an advertising fee commission payment protocol;

Figure 51 is a schematic view of a click-through fee commission payment protocol; and

Figure 52 is a schematic view of a sales commission commission payment protocol.

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DETAILED DESCRIPTION OF PREFERRED AND OTHER EMBODIMENTS

Note: Memjet™ is a trade mark of Silverbrook Research Pty Ltd, Australia.

In the preferred embodiment, the invention is configured to work with the netpage networked computer system, a detailed overview of which follows. It will be appreciated that not every implementation will necessarily embody all or even most of the specific details and extensions discussed below in relation to the basic system. However, the system is described in its most complete form to reduce the need for external reference when attempting to understand the context in which the preferred embodiments and aspects of the present invention operate.

10 In brief summary, the preferred form of the netpage system employs a computer interface in the form of a mapped surface, that is, a physical surface which contains references to a map of the surface maintained in a computer system. The map references can be queried by an appropriate sensing device. Depending upon the specific implementation, the map references may be encoded visibly or invisibly, and defined in
15 such a way that a local query on the mapped surface yields an unambiguous map reference both within the map and among different maps. The computer system can contain information about features on the mapped surface, and such information can be retrieved based on map references supplied by a sensing device used with the mapped surface. The information thus retrieved can take the form of actions which are initiated
20 by the computer system on behalf of the operator in response to the operator's interaction with the surface features.

In its preferred form, the netpage system relies on the production of, and human interaction with, netpages. These are pages of text, graphics and images printed on ordinary paper, but which work like interactive web pages. Information is encoded on
25 each page using ink which is substantially invisible to the unaided human eye. The ink, however, and thereby the coded data, can be sensed by an optically imaging pen and transmitted to the netpage system.

In the preferred form, active buttons and hyperlinks on each page can be clicked with the pen to request information from the network or to signal preferences to a
30 network server. In one embodiment, text written by hand on a netpage is automatically recognized and converted to computer text in the netpage system, allowing forms to be

As illustrated in Figure 1, a printed netpage 1 can represent a interactive form which can be filled in by the user both physically, on the printed page, and “electronically”, via communication between the pen and the netpage system. The example shows a “Request” form containing name and address fields and a submit button. The netpage consists of graphic data 2 printed using visible ink, and coded data 3 printed as a collection of tags 4 using invisible ink. The corresponding page description 5, stored on the netpage network, describes the individual elements of the netpage. In particular it describes the type and spatial extent (zone) of each interactive element (i.e. text field or button in the example), to allow the netpage system to correctly interpret input via the netpage. The submit button 6, for example, has a zone 7 which corresponds to the spatial extent of the corresponding graphic 8.

The netpage printer 601, a preferred form of which is shown in Figures 11 to 13 and described in more detail below, is able to deliver, periodically or on demand, personalized newspapers, magazines, catalogs, brochures and other publications, all printed at high quality as interactive netpages. Unlike a personal computer, the netpage printer is an appliance which can be, for example, wall-mounted adjacent to an area where the morning news is first consumed, such as in a user's kitchen, near a breakfast table, or near the household's point of departure for the day. It also comes in tabletop, desktop, portable and miniature versions.

As shown in Figure 2, the netpage pen 101 interacts with the coded data on a printed netpage 1 and communicates, via a short-range radio link 9, the interaction to a netpage printer. The printer 601 sends the interaction to the relevant netpage page server

5 The netpage system is made considerably more convenient in the preferred embodiment by being used in conjunction with high-speed microelectromechanical system (MEMS) based inkjet (Memjet™) printers. In the preferred form of this technology, relatively high-speed and high-quality printing is made more affordable to consumers. In its preferred form, a netpage publication has the physical characteristics of
10 a traditional newsmagazine, such as a set of letter-size glossy pages printed in full color on both sides, bound together for easy navigation and comfortable handling.

15 The netpage printer can also operate with slower connections, but with longer delivery times and lower image quality. Indeed, the netpage system can be enabled using existing consumer inkjet and laser printers, although the system will operate more slowly and will therefore be less acceptable from a consumer's point of view. In other embodiments, the netpage system is hosted on a private intranet. In still other embodiments, the netpage
20 system is hosted on a single computer or computer-enabled device, such as a printer.

Netpage publication servers 14 on the netpage network are configured to deliver print-quality publications to netpage printers. Periodical publications are delivered automatically to subscribing netpage printers via pointcasting and multicasting Internet protocols. Personalized publications are filtered and formatted according to individual user profiles.

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A generalization relationship (“is-a”) is drawn as a solid line joining two classes, with an arrow (in the form of an open triangle) at the generalization end.

When a class diagram is broken up into multiple diagrams, any class which is duplicated is shown with a dashed outline in all but the main diagram which defines it. It is shown with attributes only where it is defined.

1.1 NETPAGES

Netpages are the foundation on which a netpage network is built. They provide a paper-based user interface to published information and interactive services.

10 A netpage consists of a printed page (or other surface region) invisibly tagged with references to an online description of the page. The online page description is maintained persistently by a netpage page server. The page description describes the visible layout and content of the page, including text, graphics and images. It also describes the input elements on the page, including buttons, hyperlinks, and input fields.

15 A netpage allows markings made with a netpage pen on its surface to be simultaneously captured and processed by the netpage system.

Multiple netpages can share the same page description. However, to allow input through otherwise identical pages to be distinguished, each netpage is assigned a unique page identifier. This page ID has sufficient precision to distinguish between a very large number of netpages.

Each reference to the page description is encoded in a printed tag. The tag identifies the unique page on which it appears, and thereby indirectly identifies the page description. The tag also identifies its own position on the page. Characteristics of the tags are described in more detail below.

25 Tags are printed in infrared-absorptive ink on any substrate which is infrared-reflective, such as ordinary paper. Near-infrared wavelengths are invisible to the human eye but are easily sensed by a solid-state image sensor with an appropriate filter.

A tag is sensed by an area image sensor in the netpage pen, and the tag data is transmitted to the netpage system via the nearest netpage printer. The pen is wireless and communicates with the netpage printer via a short-range radio link. Tags are sufficiently

5 The netpage page server maintains a unique page instance for each printed netpage, allowing it to maintain a distinct set of user-supplied values for input fields in the page description for each printed netpage.

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1.2.1 Tag Data Content

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Field	Precision (bits)
Region ID	100
Tag ID	16
Flags	4
Total	120

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To achieve proper tag reproduction, the tag is rendered at a resolution of 256×256 dots. When printed at 1600 dots per inch this yields a tag with a diameter of about 4 mm. At this resolution the tag is designed to be surrounded by a “quiet area” of radius 16 dots. Since the quiet area is also contributed by adjacent tags, it only adds 16 dots to the effective diameter of the tag.

All target structures are redundantly large to improve their immunity to noise.

The 15 4-bit data symbols of each of the six codewords are allocated to the four concentric symbol rings 18a to 18d in interleaved fashion. Symbols are allocated alternately in circular progression around the tag.

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In order to support "single-click" interaction with a tagged region via a sensing device, the sensing device must be able to see at least one entire tag in its field of view no matter where in the region or at what orientation it is positioned. The required diameter of the field of view of the sensing device is therefore a function of the size and spacing of the tags.

Assuming a circular tag shape, the minimum diameter of the sensor field of view is obtained when the tags are tiled on a equilateral triangular grid, as shown in Figure 6.

1.2.4 Tag Image Processing and Decoding

The tag image processing and decoding performed by a sensing device such as the netpage pen is shown in Figure 7. While a captured image is being acquired from the image sensor, the dynamic range of the image is determined (at 20). The center of the range is then chosen as the binary threshold for the image 21. The image is then thresholded and segmented into connected pixel regions (i.e. shapes 23) (at 22). Shapes which are too small to represent tag target structures are discarded. The size and centroid of each shape is also computed.

Binary shape moments 25 are then computed (at 24) for each shape, and these provide the basis for subsequently locating target structures. Central shape moments are by their nature invariant of position, and can be easily made invariant of scale, aspect ratio and rotation.

The ring target structure 15 is the first to be located (at 26). A ring has the advantage of being very well behaved when perspective-distorted. Matching proceeds by aspect-normalizing and rotation-normalizing each shape's moments. Once its second-order moments are normalized the ring is easy to recognize even if the perspective distortion was significant. The ring's original aspect and rotation 27 together provide a useful approximation of the perspective transform.

The axis target structure 16 is the next to be located (at 28). Matching proceeds by applying the ring's normalizations to each shape's moments, and rotation-normalizing the resulting moments. Once its second-order moments are normalized the axis target is easily recognized. Note that one third order moment is required to disambiguate the two

possible orientations of the axis. The shape is deliberately skewed to one side to make this possible. Note also that it is only possible to rotation-normalize the axis target after it has had the ring's normalizations applied, since the perspective distortion can hide the axis target's axis. The axis target's original rotation provides a useful approximation of the tag's rotation due to pen yaw 29.

The four perspective target structures 17 are the last to be located (at 30). Good estimates of their positions are computed based on their known spatial relationships to the ring and axis targets, the aspect and rotation of the ring, and the rotation of the axis. Matching proceeds by applying the ring's normalizations to each shape's moments. Once their second-order moments are normalized the circular perspective targets are easy to recognize, and the target closest to each estimated position is taken as a match. The original centroids of the four perspective targets are then taken to be the perspective-distorted corners 31 of a square of known size in tag space, and an eight-degree-of-freedom perspective transform 33 is inferred (at 32) based on solving the well-understood equations relating the four tag-space and image-space point pairs (see Heckbert, P., Fundamentals of Texture Mapping and Image Warping, Masters Thesis, Dept. of EECS, U. of California at Berkeley, Technical Report No. UCB/CSD 89/516, June 1989, the contents of which are herein incorporated by cross-reference).

The inferred tag-space to image-space perspective transform is used to project (at 36) each known data bit position in tag space into image space where the real-valued position is used to bilinearly interpolate (at 36) the four relevant adjacent pixels in the input image. The previously computed image threshold 21 is used to threshold the result to produce the final bit value 37.

Once all 360 data bits 37 have been obtained in this way, each of the six 60-bit Reed-Solomon codewords is decoded (at 38) to yield 20 decoded bits 39, or 120 decoded bits in total. Note that the codeword symbols are sampled in codeword order, so that codewords are implicitly de-interleaved during the sampling process.

The ring target 15 is only sought in a subarea of the image whose relationship to the image guarantees that the ring, if found, is part of a complete tag. If a complete tag is not found and successfully decoded, then no pen position is recorded for the current frame. Given adequate processing power and ideally a non-minimal field of view 193, an

alternative strategy involves seeking another tag in the current image.

The obtained tag data indicates the identity of the region containing the tag and the position of the tag within the region. An accurate position 35 of the pen nib in the region, as well as the overall orientation 35 of the pen, is then inferred (at 34) from the perspective transform 33 observed on the tag and the known spatial relationship between
5 the pen's physical axis and the pen's optical axis.

1.2.5 Tag Map

Decoding a tag results in a region ID, a tag ID, and a tag-relative pen transform. Before the tag ID and the tag-relative pen location can be translated into an absolute
10 location within the tagged region, the location of the tag within the region must be known. This is given by a tag map, a function which maps each tag ID in a tagged region to a corresponding location. The tag map class diagram is shown in Figure 24, as part of the netpage printer class diagram.

A tag map reflects the scheme used to tile the surface region with tags, and this
15 can vary according to surface type. When multiple tagged regions share the same tiling scheme and the same tag numbering scheme, they can also share the same tag map.

The tag map for a region must be retrievable via the region ID. Thus, given a region ID, a tag ID and a pen transform, the tag map can be retrieved, the tag ID can be translated into an absolute tag location within the region, and the tag-relative pen
20 location can be added to the tag location to yield an absolute pen location within the region.

1.2.6 Tagging Schemes

Two distinct surface coding schemes are of interest, both of which use the tag structure described earlier in this section. The preferred coding scheme uses "location-
25 indicating" tags as already discussed. An alternative coding scheme uses object-indicating tags.

A location-indicating tag contains a tag ID which, when translated through the tag map associated with the tagged region, yields a unique tag location within the region. The tag-relative location of the pen is added to this tag location to yield the location of
30 the pen within the region. This in turn is used to determine the location of the pen

relative to a user interface element in the page description associated with the region. Not only is the user interface element itself identified, but a location relative to the user interface element is identified. Location-indicating tags therefore trivially support the capture of an absolute pen path in the zone of a particular user interface element.

- 5 An object-indicating tag contains a tag ID which directly identifies a user interface element in the page description associated with the region. All the tags in the zone of the user interface element identify the user interface element, making them all identical and therefore indistinguishable. Object-indicating tags do not, therefore, support the capture of an absolute pen path. They do, however, support the capture of a
- 10 relative pen path. So long as the position sampling frequency exceeds twice the encountered tag frequency, the displacement from one sampled pen position to the next within a stroke can be unambiguously determined.

- With either tagging scheme, the tags function in cooperation with associated visual elements on the netpage as user interactive elements in that a user can interact
- 15 with the printed page using an appropriate sensing device in order for tag data to be read by the sensing device and for an appropriate response to be generated in the netpage system.

1.3 DOCUMENT AND PAGE DESCRIPTIONS

- A preferred embodiment of a document and page description class diagram is
- 20 shown in Figures 28 and 29.

- In the netpage system a document is described at three levels. At the most abstract level the document 836 has a hierarchical structure whose terminal elements 839 are associated with content objects 840 such as text objects, text style objects, image objects, etc. Once the document is printed on a printer with a particular page size and
- 25 according to a particular user's scale factor preference, the document is paginated and otherwise formatted. Formatted terminal elements 835 will in some cases be associated with content objects which are different from those associated with their corresponding terminal elements, particularly where the content objects are style-related. Each printed instance of a document and page is also described separately, to allow input captured
- 30 through a particular page instance 830 to be recorded separately from input captured through other instances of the same page description.

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In the preferred form of the invention, a tag map 811 is associated with each page instance to allow tags on the page to be translated into locations on the page.

1.4 THE NETPAGE NETWORK

In a preferred embodiment, a netpage network consists of a distributed set of
5 netpage page servers 10, netpage registration servers 11, netpage ID servers 12, netpage application servers 13, netpage publication servers 14, and netpage printers 601 connected via a network 19 such as the Internet, as shown in Figure 3.

A netpage registration server 11 is a server which records relationships between users, pens, printers, applications and publications, and providers of various kinds, as
10 shown in Figures 21 to 27, and thereby authorizes various network activities. It authenticates users and acts as a signing proxy on behalf of authenticated users in application transactions. It also provides handwriting recognition services. The netpage network includes any number of registration servers, each identified by a unique registration server ID 63, and each handling a subset of users etc.

As described above, a netpage page server 10 maintains persistent information about page descriptions and page instances, as shown in Figures 28 to 40. The netpage network includes any number of page servers, each identified by a unique server ID 53, and each handling a subset of page instances. Since a page server also maintains user input values for each page instance, clients such as netpage printers send netpage input
15 directly to the appropriate page server. The page server interprets any such input relative to the description of the corresponding page.

As shown in Figure 22, each page server is associated with a storage provider, and the system maintains, on a registration server, an account on behalf of each storage provider, to allow it to consolidate the costs incurred by the storage provider in running
25 its page server(s). Other system participants, such as application providers and printer providers, contribute to a global fund from which the system ultimately reimburses storage providers for their running costs.

A netpage ID server 12 allocates document IDs 51 on demand, and provides load-balancing of page servers via its ID allocation scheme.

30 A netpage printer uses the Internet Distributed Name System (DNS), or similar,

to resolve a netpage page ID 50 into the network address of the netpage page server handling the corresponding page instance.

A netpage application server 13 is a server which hosts interactive netpage applications. A netpage publication server 14 is an application server which publishes
5 netpage documents to netpage printers. They are described in detail in Section 2.

Netpage servers can be hosted on a variety of network server platforms from manufacturers such as IBM, Hewlett-Packard, and Sun. Multiple netpage servers can run concurrently on a single host, and a single server can be distributed over a number of hosts. Some or all of the functionality provided by netpage servers, and in particular the
10 functionality provided by the ID server and the page server, can also be provided directly in a netpage appliance such as a netpage printer, in a computer workstation, or on a local network.

1.5 THE NETPAGE PRINTER

The netpage printer 601 is an appliance which is registered with the netpage
15 system and prints netpage documents on demand and via subscription. Each printer has a unique printer ID 62, and is connected to the netpage network via a network such as the Internet, ideally via a broadband connection.

Apart from identity and security settings in non-volatile memory, the netpage printer contains no persistent storage. As far as a user is concerned, "the network is the
20 computer". Netpages function interactively across space and time with the help of the distributed netpage page servers 10, independently of particular netpage printers.

The netpage printer receives subscribed netpage documents from netpage publication servers 14. Each document is distributed in two parts: the page layouts, and the actual text and image objects which populate the pages. Because of personalization,
25 page layouts are typically specific to a particular subscriber and so are pointcast to the subscriber's printer via the appropriate page server. Text and image objects, on the other hand, are typically shared with other subscribers, and so are multicast to all subscribers' printers and the appropriate page servers.

The netpage publication server optimizes the segmentation of document
30 content into pointcasts and multicasts. After receiving the pointcast of a document's page

layouts, the printer knows which multicasts, if any, to listen to.

Once the printer has received the complete page layouts and objects that define the document to be printed, it can print the document.

The printer rasterizes and prints odd and even pages simultaneously on both sides of the sheet. It contains duplexed print engine controllers 760 and print engines utilizing Memjet™ printheads 350 for this purpose.

The printing process consists of two decoupled stages: rasterization of page descriptions, and expansion and printing of page images. The raster image processor (RIP) consists of one or more standard DSPs 757 running in parallel. The duplexed print engine controllers consist of custom processors which expand, dither and print page images in real time, synchronized with the operation of the printheads in the print engines.

Printers not enabled for IR printing have the option to print tags using IR-absorptive black ink, although this restricts tags to otherwise empty areas of the page. Although such pages have more limited functionality than IR-printed pages, they are still classed as netpages.

A normal netpage printer prints netpages on sheets of paper. More specialised netpage printers may print onto more specialised surfaces, such as globes. Each printer supports at least one surface type, and supports at least one tag tiling scheme, and hence tag map, for each surface type. The tag map 811 which describes the tag tiling scheme actually used to print a document becomes associated with that document so that the document's tags can be correctly interpreted.

Figure 2 shows the netpage printer class diagram, reflecting printer-related information maintained by a registration server 11 on the netpage network.

A preferred embodiment of the netpage printer is described in greater detail in Section 6 below, with reference to Figures 11 to 16.

1.5.1 Memjet™ Printheads

The netpage system can operate using printers made with a wide range of digital printing technologies, including thermal inkjet, piezoelectric inkjet, laser

- photographic quality color printing

- high reliability

- low ink cost

- simple operation

- high printing speed

- compact form factor

15 No commercially available printing technology has all of these characteristics.

20 a single printing element 300 of a Memjet™ printhead. The netpage wallprinter incorporates 168960 printing elements 300 to form a 1600 dpi pagewidth duplex printer. This printer simultaneously prints cyan, magenta, yellow, black, and infrared inks as well as paper conditioner and ink fixative.

25 wide. Arrays of these printing elements are formed on a silicon substrate 301 that
incorporates CMOS logic, data transfer, timing, and drive circuits (not shown).

Major elements of the printing element 300 are the nozzle 302, the nozzle rim 303, the nozzle chamber 304, the fluidic seal 305, the ink channel rim 306, the lever arm

The active actuator beam pair 308 is mechanically joined to the passive actuator beam pair 309 at the join 319. Both beams pairs are anchored at their respective anchor points 310 and 311. The combination of elements 308, 309, 310, 311, and 319 form a cantilevered electrothermal bend actuator 320.

10 Figures 19(a), 19(b) and 19(c) show the operating cycle of a Memjet™ printing
element 300.

Figure 19(a) shows the quiescent position of the ink meniscus 316 prior to printing an ink droplet. Ink is retained in the nozzle chamber by surface tension at the ink meniscus 316 and at the fluidic seal 305 formed between the nozzle chamber 304 and the ink channel rim 306.

While printing, the printhead CMOS circuitry distributes data from the print engine controller to the correct printing element, latches the data, and buffers the data to drive the electrodes 318 of the active actuator beam pair 308. This causes an electrical current to pass through the beam pair 308 for about one microsecond, resulting in Joule heating. The temperature increase resulting from Joule heating causes the beam pair 308 to expand. As the passive actuator beam pair 309 is not heated, it does not expand, resulting in a stress difference between the two beam pairs. This stress difference is partially resolved by the cantilevered end of the electrothermal bend actuator 320 bending towards the substrate 301. The lever arm 307 transmits this movement to the nozzle chamber 304. The nozzle chamber 304 moves about two microns to the position shown in Figure 19(b). This increases the ink pressure, forcing ink 321 out of the nozzle 302, and causing the ink meniscus 316 to bulge. The nozzle rim 303 prevents the ink meniscus 316 from spreading across the surface of the nozzle chamber 304.

As the temperature of the beam pairs 308 and 309 equalizes, the actuator 320 returns to its original position. This aids in the break-off of the ink droplet 317 from the

ink 321 in the nozzle chamber, as shown in Figure 19(c). The nozzle chamber is refilled by the action of the surface tension at the meniscus 316.

Figure 20 shows a segment of a printhead 350. In a netpage printer, the length of the printhead is the full width of the paper (typically 210 mm) in the direction 351.

5 The segment shown is 0.4 mm long (about 0.2% of a complete printhead). When printing, the paper is moved past the fixed printhead in the direction 352. The printhead has 6 rows of interdigitated printing elements 300, printing the six colors or types of ink supplied by the ink inlets 312.

To protect the fragile surface of the printhead during operation, a nozzle guard wafer 330 is attached to the printhead substrate 301. For each nozzle 302 there is a corresponding nozzle guard hole 331 through which the ink droplets are fired. To prevent the nozzle guard holes 331 from becoming blocked by paper fibers or other debris, filtered air is pumped through the air inlets 332 and out of the nozzle guard holes during printing. To prevent ink 321 from drying, the nozzle guard is sealed while the printer is idle.

1.6 The Netpage Pen

The active sensing device of the netpage system is typically a pen 101, which, using its embedded controller 134, is able to capture and decode IR position tags from a page via an image sensor. The image sensor is a solid-state device provided with an appropriate filter to permit sensing at only near-infrared wavelengths. As described in more detail below, the system is able to sense when the nib is in contact with the surface, and the pen is able to sense tags at a sufficient rate to capture human handwriting (i.e. at 200 dpi or greater and 100 Hz or faster). Information captured by the pen is encrypted and wirelessly transmitted to the printer (or base station), the printer or base station interpreting the data with respect to the (known) page structure.

The preferred embodiment of the netpage pen operates both as a normal marking ink pen and as a non-marking stylus. The marking aspect, however, is not necessary for using the netpage system as a browsing system, such as when it is used as an Internet interface. Each netpage pen is registered with the netpage system and has a unique pen ID 61. Figure 25 shows the netpage pen class diagram, reflecting pen-related information maintained by a registration server 11 on the netpage network.

When either nib is in contact with a netpage, the pen determines its position and orientation relative to the page. The nib is attached to a force sensor, and the force on the nib is interpreted relative to a threshold to indicate whether the pen is “up” or “down”. This allows a interactive element on the page to be ‘clicked’ by pressing with the pen nib, in order to request, say, information from a network. Furthermore, the force is captured as a continuous value to allow, say, the full dynamics of a signature to be verified.

The pen determines the position and orientation of its nib on the netpage by imaging, in the infrared spectrum, an area 193 of the page in the vicinity of the nib. It decodes the nearest tag and computes the position of the nib relative to the tag from the observed perspective distortion on the imaged tag and the known geometry of the pen optics. Although the position resolution of the tag may be low, because the tag density on the page is inversely proportional to the tag size, the adjusted position resolution is quite high, exceeding the minimum resolution required for accurate handwriting recognition.

Pen actions relative to a netpage are captured as a series of strokes. A stroke consists of a sequence of time-stamped pen positions on the page, initiated by a pen-down event and completed by the subsequent pen-up event. A stroke is also tagged with the page ID 50 of the netpage whenever the page ID changes, which, under normal circumstances, is at the commencement of the stroke.

Each netpage pen has a current selection 826 associated with it, allowing the user to perform copy and paste operations etc. The selection is timestamped to allow the system to discard it after a defined time period. The current selection describes a region of a page instance. It consists of the most recent digital ink stroke captured through the pen relative to the background area of the page. It is interpreted in an application-specific manner once it is submitted to an application via a selection hyperlink activation.

Each pen has a current nib 824. This is the nib last notified by the pen to the system. In the case of the default netpage pen described above, either the marking black ink nib or the non-marking stylus nib is current. Each pen also has a current nib style 825. This is the nib style last associated with the pen by an application, e.g. in response to the user selecting a color from a palette. The default nib style is the nib style

associated with the current nib. Strokes captured through a pen are tagged with the current nib style. When the strokes are subsequently reproduced, they are reproduced in the nib style with which they are tagged.

Whenever the pen is within range of a printer with which it can communicate,
5 the pen slowly flashes its “online” LED. When the pen fails to decode a stroke relative to
the page, it momentarily activates its “error” LED. When the pen succeeds in decoding a
stroke relative to the page, it momentarily activates its “ok” LED.

A sequence of captured strokes is referred to as digital ink. Digital ink forms the basis for the digital exchange of drawings and handwriting, for online recognition of
10 handwriting, and for online verification of signatures.

The pen is wireless and transmits digital ink to the netpage printer via a short-range radio link. The transmitted digital ink is encrypted for privacy and security and packetized for efficient transmission, but is always flushed on a pen-up event to ensure timely handling in the printer.

15 When the pen is out-of-range of a printer it buffers digital ink in internal memory, which has a capacity of over ten minutes of continuous handwriting. When the pen is once again within range of a printer, it transfers any buffered digital ink.

A pen can be registered with any number of printers, but because all state data resides in netpages both on paper and on the network, it is largely immaterial which printer a pen is communicating with at any particular time.

A preferred embodiment of the pen is described in greater detail in Section 6 below, with reference to Figures 8 to 10.

1.7 NETPAGE INTERACTION

The netpage printer 601 receives data relating to a stroke from the pen 101 when the pen is used to interact with a netpage 1. The coded data 3 of the tags 4 is read by the pen when it is used to execute a movement, such as a stroke. The data allows the identity of the particular page and associated interactive element to be determined and an indication of the relative positioning of the pen relative to the page to be obtained. The indicating data is transmitted to the printer, where it resolves, via the DNS, the page ID 50 of the stroke into the network address of the netpage page server 10 which maintains

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There are two kinds of input elements in a netpage page description: hyperlinks and form fields. Input through a form field can also trigger the activation of an associated hyperlink.

1.7.1 Hyperlinks

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contains a set of terminal field elements 839. A form instance 868 represents a printed

instance of a form. It consists of a set of field instances 870 which correspond to the field elements 845 of the form. Each field instance has an associated value 871, whose type depends on the type of the corresponding field element. Each field value records input through a particular printed form instance, i.e. through one or more printed netpages. The
5 form class diagram is shown in Figure 35.

Each form instance has a status 872 which indicates whether the form is active, frozen, submitted, void or expired. A form is active when first printed. A form becomes frozen once it is signed or once its freeze time is reached. A form becomes submitted once one of its submission hyperlinks has been activated, unless the hyperlink has its
10 “submit delta” attribute set. A form becomes void when the user invokes a void form, reset form or duplicate form page command. A form expires when its specified expiry time is reached, i.e. when the time the form has been active exceeds the form’s specified lifetime. While the form is active, form input is allowed. Input through a form which is not active is instead captured in the background field 833 of the relevant page instance.
15 When the form is active or frozen, form submission is allowed. Any attempt to submit a form when the form is not active or frozen is rejected, and instead elicits an form status report.

Each form instance is associated (at 59) with any form instances derived from it, thus providing a version history. This allows all but the latest version of a form in a
20 particular time period to be excluded from a search.

All input is captured as digital ink. Digital ink 873 consists of a set of timestamped stroke groups 874, each of which consists of a set of styled strokes 875. Each stroke consists of a set of timestamped pen positions 876, each of which also includes pen orientation and nib force. The digital ink class diagram is shown in Figure
25 36.

A field element 845 can be a checkbox field 877, a text field 878, a drawing field 879, or a signature field 880. The field element class diagram is shown in Figure 37. Any digital ink captured in a field’s zone 58 is assigned to the field.

A checkbox field has an associated boolean value 881, as shown in Figure 38.
30 Any mark (a tick, a cross, a stroke, a fill zigzag, etc.) captured in a checkbox field’s zone causes a true value to be assigned to the field’s value.

A text field has an associated text value 882, as shown in Figure 39. Any digital ink captured in a text field's zone is automatically converted to text via online handwriting recognition, and the text is assigned to the field's value. Online handwriting recognition is well-understood (see, for example, Tappert, C., C.Y. Suen and T. Wakahara, "The State of the Art in On-Line Handwriting Recognition", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.12, No.8, August 1990, the contents of which are herein incorporated by cross-reference).

A signature field has an associated digital signature value 883, as shown in Figure 40. Any digital ink captured in a signature field's zone is automatically verified with respect to the identity of the owner of the pen, and a digital signature of the content of the form of which the field is part is generated and assigned to the field's value. The digital signature is generated using the pen user's private signature key specific to the application which owns the form. Online signature verification is well-understood (see, for example, Plamondon, R. and G. Lorette, "Automatic Signature Verification and Writer Identification – The State of the Art", Pattern Recognition, Vol.22, No.2, 1989, the contents of which are herein incorporated by cross-reference).

A field element is hidden if its "hidden" attribute is set. A hidden field element does not have an input zone on a page and does not accept input. It can have an associated field value which is included in the form data when the form containing the field is submitted.

"Editing" commands, such as strike-throughs indicating deletion, can also be recognized in form fields.

Because the handwriting recognition algorithm works "online" (i.e. with access to the dynamics of the pen movement), rather than "offline" (i.e. with access only to a bitmap of pen markings), it can recognize run-on discretely-written characters with relatively high accuracy, without a writer-dependent training phase. A writer-dependent model of handwriting is automatically generated over time, however, and can be generated up-front if necessary,

Digital ink, as already stated, consists of a sequence of strokes. Any stroke which starts in a particular element's zone is appended to that element's digital ink stream, ready for interpretation. Any stroke not appended to an object's digital ink

stream is appended to the background field's digital ink stream.

Digital ink captured in the background field is interpreted as a selection gesture. Circumscription of one or more objects is generally interpreted as a selection of the circumscribed objects, although the actual interpretation is application-specific.

- 5 Table 2 summarises these various pen interactions with a netpage.

Table 2 - Summary of pen interactions with a netpage

Object	Type	Pen input	Action
Hyperlink	General	Click	Submit action to application
	Form	Click	Submit form to application
	Selection	Click	Submit selection to application
Form field	Checkbox	Any mark	Assign true to field
	Text	Handwriting	Convert digital ink to text; assign text to field
	Drawing	Digital ink	Assign digital ink to field
	Signature	Signature	Verify digital ink signature; generate digital signature of form; assign digital signature to field
None	-	Circumscription	Assign digital ink to current selection

- 10 The system maintains a current selection for each pen. The selection consists simply of the most recent stroke captured in the background field. The selection is cleared after an inactivity timeout to ensure predictable behavior.

- 15 The raw digital ink captured in every field is retained on the netpage page server and is optionally transmitted with the form data when the form is submitted to the application. This allows the application to interrogate the raw digital ink should it suspect the original conversion, such as the conversion of handwritten text. This can, for example, involve human intervention at the application level for forms which fail certain application-specific consistency checks. As an extension to this, the entire background area of a form can be designated as a drawing field. The application can then decide, on the basis of the presence of digital ink outside the explicit fields of the form, to route the
- 20 form to a human operator, on the assumption that the user may have indicated amendments to the filled-in fields outside of those fields.

Figure 38 shows a flowchart of the process of handling pen input relative to a netpage. The process consists of receiving (at 884) a stroke from the pen; identifying (at 885) the page instance 830 to which the page ID 50 in the stroke refers; retrieving (at 886) the page description 5; identifying (at 887) a formatted element 839 whose zone 58 the stroke intersects; determining (at 888) whether the formatted element corresponds to a field element, and if so appending (at 892) the received stroke to the digital ink of the field value 871, interpreting (at 893) the accumulated digital ink of the field, and determining (at 894) whether the field is part of a hyperlinked group 866 and if so activating (at 895) the associated hyperlink; alternatively determining (at 889) whether the formatted element corresponds to a hyperlink element and if so activating (at 895) the corresponding hyperlink; alternatively, in the absence of an input field or hyperlink, appending (at 890) the received stroke to the digital ink of the background field 833; and copying (at 891) the received stroke to the current selection 826 of the current pen, as maintained by the registration server.

Figure 38a shows a detailed flowchart of step 893 in the process shown in Figure 41, where the accumulated digital ink of a field is interpreted according to the type of the field. The process consists of determining (at 896) whether the field is a checkbox and (at 897) whether the digital ink represents a checkmark, and if so assigning (at 898) a true value to the field value; alternatively determining (at 899) whether the field is a text field and if so converting (at 900) the digital ink to computer text, with the help of the appropriate registration server, and assigning (at 901) the converted computer text to the field value; alternatively determining (at 902) whether the field is a signature field and if so verifying (at 903) the digital ink as the signature of the pen's owner, with the help of the appropriate registration server, creating (at 904) a digital signature of the contents of the corresponding form, also with the help of the registration server and using the pen owner's private signature key relating to the corresponding application, and assigning (at 905) the digital signature to the field value.

1.7.3 Page Server Commands

A page server command is a command which is handled locally by the page server. It operates directly on form, page and document instances.

A page server command 907 can be a void form command, a duplicate form

command, a reset form command, a get form status command, a duplicate page command, a reset page command, a get page status command, a duplicate document command, a reset document command, or a get document status command.

A void form command voids the corresponding form instance. A duplicate form command voids the corresponding form instance and then produces an active printed copy of the current form instance with field values preserved. The copy contains the same hyperlink transaction IDs as the original, and so is indistinguishable from the original to an application. A reset form command voids the corresponding form instance and then produces an active printed copy of the form instance with field values discarded. A get form status command produces a printed report on the status of the corresponding form instance, including who published it, when it was printed, for whom it was printed, and the form status of the form instance.

Since a form hyperlink instance contains a transaction ID, the application has to be involved in producing a new form instance. A button requesting a new form instance is therefore typically implemented as a hyperlink.

A duplicate page command produces a printed copy of the corresponding page instance with the background field value preserved. If the page contains a form or is part of a form, then the duplicate page command is interpreted as a duplicate form command. A reset page command produces a printed copy of the corresponding page instance with the background field value discarded. If the page contains a form or is part of a form, then the reset page command is interpreted as a reset form command. A get page status command produces a printed report on the status of the corresponding page instance, including who published it, when it was printed, for whom it was printed, and the status of any forms it contains or is part of.

25 The netpage logo which appears on every netpage is usually associated with a duplicate page element.

When a page instance is duplicated with field values preserved, field values are printed in their native form, i.e. a checkmark appears as a standard checkmark graphic, and text appears as typeset text. Only drawings and signatures appear in their original form, with a signature accompanied by a standard graphic indicating successful signature verification.

A duplicate document command produces a printed copy of the corresponding document instance with background field values preserved. If the document contains any forms, then the duplicate document command duplicates the forms in the same way a duplicate form command does. A reset document command produces a printed copy of the corresponding document instance with background field values discarded. If the document contains any forms, then the reset document command resets the forms in the same way a reset form command does. A get document status command produces a printed report on the status of the corresponding document instance, including who published it, when it was printed, for whom it was printed, and the status of any forms it contains.

If the page server command's "on selected" attribute is set, then the command operates on the page identified by the pen's current selection rather than on the page containing the command. This allows a menu of page server commands to be printed. If the target page doesn't contain a page server command element for the designated page server command, then the command is ignored.

An application can provide application-specific handling by embedding the relevant page server command element in a hyperlinked group. The page server activates the hyperlink associated with the hyperlinked group rather than executing the page server command.

A page server command element is hidden if its "hidden" attribute is set. A hidden command element does not have an input zone on a page and so cannot be activated directly by a user. It can, however, be activated via a page server command embedded in a different page, if that page server command has its "on selected" attribute set.

1.8 STANDARD FEATURES OF NETPAGES

In the preferred form, each netpage is printed with the netpage logo at the bottom to indicate that it is a netpage and therefore has interactive properties. The logo also acts as a copy button. In most cases pressing the logo produces a copy of the page. In the case of a form, the button produces a copy of the entire form. And in the case of a secure document, such as a ticket or coupon, the button elicits an explanatory note or advertising page.

The default single-page copy function is handled directly by the relevant netpage page server. Special copy functions are handled by linking the logo button to an application.

1.9 USER HELP SYSTEM

5 In a preferred embodiment, the netpage printer has a single button labelled
 “Help”. When pressed it elicits a single help page 46 of information, including:

- status of printer connection
- status of printer consumables
- top-level help menu
- 10 • document function menu
- top-level netpage network directory

The help menu provides a hierarchical manual on how to use the netpage system.

The document function menu includes the following functions:

- print a copy of a document
- print a clean copy of a form
- print the status of a document

A document function is initiated by selecting the document and then pressing the button. The status of a document indicates who published it and when, to whom it was delivered, and to whom and when it was subsequently submitted as a form.

The help page is obviously unavailable if the printer is unable to print. In this case the “error” light is lit and the user can request remote diagnosis over the network.

2 PERSONALIZED PUBLICATION MODEL

In the following description, news is used as a canonical publication example to illustrate personalization mechanisms in the netpage system. Although news is often used in the limited sense of newspaper and newsmagazine news, the intended scope in the present context is wider.

In the netpage system, the editorial content and the advertising content of a news publication are personalized using different mechanisms. The editorial content is personalized according to the reader's explicitly stated and implicitly captured interest profile. The advertising content is personalized according to the reader's locality and demographic.

2.1 EDITORIAL PERSONALIZATION

A subscriber can draw on two kinds of news sources: those that deliver news publications, and those that deliver news streams. While news publications are aggregated and edited by the publisher, news streams are aggregated either by a news publisher or by a specialized news aggregator. News publications typically correspond to traditional newspapers and newsmagazines, while news streams can be many and varied: a "raw" news feed from a news service, a cartoon strip, a freelance writer's column, a friend's bulletin board, or the reader's own e-mail.

The netpage publication server supports the publication of edited news publications as well as the aggregation of multiple news streams. By handling the aggregation and hence the formatting of news streams selected directly by the reader, the server is able to place advertising on pages over which it otherwise has no editorial control.

The subscriber builds a daily newspaper by selecting one or more contributing news publications, and creating a personalized version of each. The resulting daily editions are printed and bound together into a single newspaper. The various members of a household typically express their different interests and tastes by selecting different daily publications and then customizing them.

For each publication, the reader optionally selects specific sections. Some sections appear daily, while others appear weekly. The daily sections available from The New York Times online, for example, include "Page One Plus", "National", "International", "Opinion", "Business", "Arts/Living", "Technology", and "Sports". The set of available sections is specific to a publication, as is the default subset.

The reader can extend the daily newspaper by creating custom sections, each one drawing on any number of news streams. Custom sections might be created for e-

For each section, the reader optionally specifies its size, either qualitatively (e.g. short, medium, or long), or numerically (i.e. as a limit on its number of pages), and the desired proportion of advertising, either qualitatively (e.g. high, normal, low, none), or numerically (i.e. as a percentage).

10 An article may also be written (or edited) in different versions to match the expected sophistication of the reader, for example to provide children's and adults' versions. The appropriate version is selected according to the reader's age. The reader can specify a "reading age" which takes precedence over their biological age.

In sections where it is appropriate, the reader may optionally enable collaborative filtering. This is then applied to articles which have a sufficiently long
20 lifetime. Each article which qualifies for collaborative filtering is printed with rating buttons at the end of the article. The buttons can provide an easy choice (e.g. “liked” and “disliked”), making it more likely that readers will bother to rate the article.

The reader optionally specifies a serendipity factor, either qualitatively (e.g. do or don't surprise me), or numerically. A high serendipity factor lowers the threshold used for matching during collaborative filtering. A high factor makes it more likely that the corresponding section will be filled to the reader's specified capacity. A different serendipity factor can be specified for different days of the week.

The speed of the reader's Internet connection affects the quality at which images can be delivered. The reader optionally specifies a preference for fewer images or smaller images or both. If the number or size of images is not reduced, then images may be delivered at lower quality (i.e. at lower resolution or with greater compression).

To reduce reading difficulties caused by poor eyesight, the reader optionally specifies a global preference for a larger presentation. Both text and images are scaled accordingly, and less information is accommodated on each page.

15 The language in which a news publication is published, and its corresponding text encoding, is a property of the publication and not a preference expressed by the user. However, the netpage system can be configured to provide automatic translation services in various guises.

2.2 ADVERTISING LOCALIZATION AND TARGETING

20 The personalization of the editorial content directly affects the advertising content, because advertising is typically placed to exploit the editorial context. Travel ads, for example, are more likely to appear in a travel section than elsewhere. The value of the editorial content to an advertiser (and therefore to the publisher) lies in its ability to attract large numbers of readers with the right demographics.

25 Effective advertising is placed on the basis of locality and demographics. Locality determines proximity to particular services, retailers etc., and particular interests and concerns associated with the local community and environment. Demographics determine general interests and preoccupations as well as likely spending patterns.

A news publisher's most profitable product is advertising "space", a multi-
30 dimensional entity determined by the publication's geographic coverage, the size of its

In the netpage system, the netpage publication server computes the approximate multi-dimensional size of a publication's saleable advertising space on a per-section basis, taking into account the publication's geographic coverage, the section's readership, the size of each reader's section edition, each reader's advertising proportion, and each reader's demographic.

10 For example, the same advertising “slot” can be sold in varying proportions to several advertisers, with individual readers’ pages randomly receiving the advertisement of one advertiser or another, overall preserving the proportion of space sold to each advertiser.

Because personalization and localization are handled automatically by netpage publication servers, an advertising aggregator can provide arbitrarily broad coverage of both geography and demographics. The subsequent disaggregation is efficient because it is automatic. This makes it more cost-effective for publishers to deal with advertising aggregators than to directly capture advertising. Even though the advertising aggregator is taking a proportion of advertising revenue, publishers may find the change profit-neutral because of the greater efficiency of aggregation. The advertising aggregator acts as an intermediary between advertisers and publishers, and may place the same advertisement in multiple publications.

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Once placement has been negotiated, the aggregator captures and edits the advertisement and records it on a netpage ad server. Correspondingly, the publisher records the ad placement on the relevant netpage publication server. When the netpage publication server lays out each user's personalized publication, it picks the relevant advertisements from the netpage ad server.

10 2.3.1 Information Filtering

- publication customizations
- collaborative filtering vectors
- contact details
- presentation preferences

A collaborative filtering vector consists of the user's ratings of a number of news items. It is used to correlate different users' interests for the purposes of making recommendations. Although there are benefits to maintaining a single collaborative filtering vector independently of any particular publication, there are two reasons why it is more practical to maintain a separate vector for each publication: there is likely to be more overlap between the vectors of subscribers to the same publication than between those of subscribers to different publications; and a publication is likely to want to present its users' collaborative filtering vectors as part of the value of its brand, not to be found elsewhere. Collaborative filtering vectors are therefore also maintained by the relevant netpage publication server.

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telephone numbers, are global by nature, and are maintained by a netpage registration server.

Presentation preferences, including those for quantities, dates and times, are likewise global and maintained in the same way.

- 5 The localization of advertising relies on the locality indicated in the user's contact details, while the targeting of advertising relies on personal information such as date of birth, gender, marital status, income, profession, education, or qualitative derivatives such as age range and income range.

- 10 For those users who choose to reveal personal information for advertising purposes, the information is maintained by the relevant netpage registration server. In the absence of such information, advertising can be targeted on the basis of the demographic associated with the user's ZIP or ZIP+4 Code.

- 15 Each user, pen, printer, application provider and application is assigned its own unique identifier, and the netpage registration server maintains the relationships between them, as shown in Figures 23, 24, 25 and 26. For registration purposes, a publisher is a special kind of application provider, and a publication is a special kind of application.

- 20 Each user 800 may be authorized to use any number of printers 802, and each printer may allow any number of users to use it. Each user has a single default printer (at 66), to which periodical publications are delivered by default, whilst pages printed on demand are delivered to the printer through which the user is interacting. The server keeps track of which publishers a user has authorized to print to the user's default printer. A publisher does not record the ID of any particular printer, but instead resolves the ID when it is required. The user may also be designated as having administrative privileges 69 on the printer, allowing the user to authorize other users to use the printer.
- 25 This only has meaning if the printer requires administrative privileges 84 for such operations.

- 30 When a user subscribes 808 to a publication 807, the publisher 806 (i.e. application provider 803) is authorized to print to a specified printer or the user's default printer. This authorization can be revoked at any time by the user. Each user may have several pens 801, but a pen is specific to a single user. If a user is authorized to use a

particular printer, then that printer recognizes any of the user's pens.

The pen ID is used to locate the corresponding user profile maintained by a particular netpage registration server, via the DNS in the usual way.

A Web terminal 809 can be authorized to print on a particular netpage printer, allowing Web pages and netpage documents encountered during Web browsing to be conveniently printed on the nearest netpage printer.

The netpage system can collect, on behalf of a printer provider, fees and commissions on income earned through publications printed on the provider's printers. Such income can include advertising fees, click-through fees, e-commerce commissions, and transaction fees. If the printer is owned by the user, then the user is the printer provider.

Each user also has a netpage account 820 which is used to accumulate micro-debits and credits (such as those described in the preceding paragraph); contact details 815, including name, address and telephone numbers; global preferences 816, including privacy, delivery and localization settings; any number of biometric records 817, containing the user's encoded signature 818, fingerprint 819 etc; a handwriting model 819 automatically maintained by the system; and SET payment card accounts 821, with which e-commerce payments can be made.

In addition to the user-specific netpage account, each user also has a netpage account 936 specific to each printer the user is authorized to use. Each printer-specific account is used to accumulate micro-debits and credits related to the user's activities on that printer. The user is billed on a regular basis for any outstanding debit balances.

A user optionally appears in the netpage user directory 823, allowing other users to locate and direct e-mail (etc.) to the user.

2.4 INTELLIGENT PAGE LAYOUT

The netpage publication server automatically lays out the pages of each user's personalized publication on a section-by-section basis. Since most advertisements are in the form of pre-formatted rectangles, they are placed on the page before the editorial content.

The advertising ratio for a section can be achieved with wildly varying

5 The editorial content selected for the user, including text and associated images and graphics, is then laid out according to various aesthetic rules.

10 however, be matched *on average* over time, allowing significant day-to-day variations.

Once the document is laid out, it is encoded for efficient distribution and persistent storage on the netpage network.

single user's edition and information shared between multiple users' editions. The specific information consists of the page layout. The shared information consists of the objects to which the page layout refers, including images, graphics, and pieces of text.

20 provides precise control over text formatting independently of the region into which the text is being set, which in this case is being provided by the layout. The text object contains embedded language codes to enable automatic translation, and embedded hyphenation hints to aid with paragraph formatting.

25 compressed image format. A graphic object encodes a 2D graphic in Scalable Vector Graphics (SVG) format.

30 3. The layout uses a compact format suitable for efficient distribution and storage.

Table 3 - netpage layout objects

Layout object	Attribute	Format of linked object
Image	Position	-
	Image object ID	JPEG 2000
Graphic	Position	-
	Graphic object ID	SVG
Textflow	Textflow ID	-
	Zone	-
	Optional text object ID	XML/XSL
Hyperlink	Type	-
	Zone	-
	Application ID, etc.	-
Field	Type	-
	Meaning	-
	Zone	-
Watermark	Zone	-

2.6 DOCUMENT DISTRIBUTION

- 5 As described above, for purposes of efficient distribution and persistent storage on the netpage network, a user-specific page layout is separated from the shared objects to which it refers.

When a subscribed publication is ready to be distributed, the netpage publication server allocates, with the help of the netpage ID server 12, a unique ID for each page, page instance, document, and document instance.

10 The server computes a set of optimized subsets of the shared content and creates a multicast channel for each subset, and then tags each user-specific layout with the names of the multicast channels which will carry the shared content used by that layout. The server then pointcasts each user's layouts to that user's printer via the appropriate page server, and when the pointcasting is complete, multicasts the shared content on the specified channels. After receiving its pointcast, each page server and printer subscribes to the multicast channels specified in the page layouts. During the multicasts, each page server and printer extracts from the multicast streams those objects referred to by its page layouts. The page servers persistently archive the received page layouts and shared content.

Under normal circumstances, the printer prints pages faster than they can be delivered. Assuming a quarter of each page is covered with images, the average page has a size of less than 400KB. The printer can therefore hold in excess of 100 such pages in its internal 64MB memory, allowing for temporary buffers etc. The printer prints at a rate of one page per second. This is equivalent to 400KB or about 3Mbit of page data per second, which is similar to the highest expected rate of page data delivery over a broadband network.

However, if the printer's internal memory does fill up, then the printer will be unable to make use of a multicast when it first occurs. The netpage publication server therefore allows printers to submit requests for re-multicasts. When a critical number of requests is received or a timeout occurs, the server re-multicasts the corresponding shared objects.

20 2.7 ON-DEMAND DOCUMENTS

When a non-netpage document is requested on demand, it is not personalized, and it is delivered via a designated netpage formatting server which reformats it as a netpage document. A netpage formatting server is a special instance of a netpage publication server. The netpage formatting server has knowledge of various Internet document formats, including Adobe's Portable Document Format (PDF), and Hypertext Markup Language (HTML). In the case of HTML, it can make use of the higher resolution of the printed page to present Web pages in a multi-column format, with a

The netpage formatting server makes standard netpage behavior, including interactivity and persistence, available on any Internet document, no matter what its origin and format. It hides knowledge of different document formats from both the netpage printer and the netpage page server, and hides knowledge of the netpage system from Web servers.

3.1 CRYPTOGRAPHY

15 Secret-key cryptography, also referred to as symmetric cryptography, uses the same key to encrypt and decrypt a message. Two parties wishing to exchange messages must first arrange to securely exchange the secret key.

Public-key cryptography can be used to create a digital signature. The holder of the private key can create a known hash of a message and then encrypt the hash using the private key. Anyone can then verify that the encrypted hash constitutes the “signature” of the holder of the private key with respect to that particular message by decrypting the encrypted hash using the public key and verifying the hash against the message. If the

signature is appended to the message, then the recipient of the message can verify both that the message is genuine and that it has not been altered in transit.

To make public-key cryptography work, there has to be a way to distribute public keys which prevents impersonation. This is normally done using certificates and certificate authorities. A certificate authority is a trusted third party which authenticates the connection between a public key and someone's identity. The certificate authority verifies the person's identity by examining identity documents, and then creates and signs a digital certificate containing the person's identity details and public key. Anyone who trusts the certificate authority can use the public key in the certificate with a high degree of certainty that it is genuine. They just have to verify that the certificate has indeed been signed by the certificate authority, whose public key is well-known.

In most transaction environments, public-key cryptography is only used to create digital signatures and to securely exchange secret session keys. Secret-key cryptography is used for all other purposes.

In the following discussion, when reference is made to the *secure* transmission of information between a netpage printer and a server, what actually happens is that the printer obtains the server's certificate, authenticates it with reference to the certificate authority, uses the public key-exchange key in the certificate to exchange a secret session key with the server, and then uses the secret session key to encrypt the message data. A *session* key, by definition, can have an arbitrarily short lifetime.

3.2 NETPAGE PRINTER SECURITY

Each netpage printer is assigned a pair of unique identifiers at time of manufacture which are stored in read-only memory in the printer and in the netpage registration server database. The first ID 62 is public and uniquely identifies the printer on the netpage network. The second ID is secret and is used when the printer is first registered on the network.

When the printer connects to the netpage network for the first time after installation, it creates a signature public/private key pair. It transmits the secret ID and the public key securely to the netpage registration server. The server compares the secret ID against the printer's secret ID recorded in its database, and accepts the registration if

The netpage registration server acts as a certificate authority for netpage printers, since it has access to secret information allowing it to verify printer identity.

When a user subscribes to a publication, a record is created in the netpage registration server database authorizing the publisher to print the publication to the user's default printer or a specified printer. Every document sent to a printer via a page server is addressed to a particular user and is signed by the publisher using the publisher's private signature key. The page server verifies, via the registration database, that the publisher is authorized to deliver the publication to the specified user. The page server verifies the signature using the publisher's public key, obtained from the publisher's certificate stored in the registration database.

The netpage registration server accepts requests to add printing authorizations to the database, so long as those requests are initiated via a pen registered to the printer.

15 3.3 NETPAGE PEN SECURITY

Each netpage pen is assigned a unique identifier at time of manufacture which is stored in read-only memory in the pen and in the netpage registration server database. The pen ID 61 uniquely identifies the pen on the netpage network.

A netpage pen can “know” a number of netpage printers, and a printer can “know” a number of pens. A pen communicates with a printer via a radio frequency signal whenever it is within range of the printer. Once a pen and printer are registered, they regularly exchange session keys. Whenever the pen transmits digital ink to the printer, the digital ink is always encrypted using the appropriate session key. Digital ink is never transmitted in the clear.

25 A pen stores a session key for every printer it knows, indexed by printer ID, and a printer stores a session key for every pen it knows, indexed by pen ID. Both have a large but finite storage capacity for session keys, and will forget a session key on a least-recently-used basis if necessary.

When a pen comes within range of a printer, the pen and printer discover
30 whether they know each other. If they don't know each other, then the printer determines

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performance constraints in the pen.

3.4 SECURE DOCUMENTS

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The effect is similar to a watermark in that it is not visible when looking at only one side of the page, and is lost when the page is copied by normal means.

Secure documents are typically generated as part of e-commerce transactions. They can therefore include the user's photograph which was captured when the user registered biometric information with the netpage registration server, as described in Section 2.

Clearly neither the watermark nor the user's photograph are secure in a cryptographic sense. They simply provide a significant obstacle to casual forgery. Online document verification, particularly using a verification pen, provides an added level of security where it is needed, but is still not entirely immune to forgeries.

In the netpage system, forms submitted by users are delivered reliably to forms handlers and are persistently archived on netpage page servers. It is therefore impossible for recipients to repudiate delivery.

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4.1 SECURE ELECTRONIC TRANSACTION (SET)

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4.2 SET PAYMENTS

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5 act as the user's proxy in any SET payment transaction.

10 then on acts as the user's proxy in completing the SET payment transaction.

4.3 MICRO-PAYMENTS

15 expenses incurred in printing advertising material. The latter depends on the level of
subsidy already provided to the user.

When the user registers for e-commerce, a network account is established which aggregates micro-payments. The user receives a statement on a regular basis, and can settle any outstanding debit balance using the standard payment mechanism.

20 The network account can be extended to aggregate subscription fees for periodicals, which would also otherwise be presented to the user in the form of individual statements.

4.4 TRANSACTIONS

25 application is able to embed a user-specific transaction ID 55 in the page. Subsequent input through the page is tagged with the transaction ID, and the application is thereby able to establish an appropriate context for the user's input.

30 involves adding items from a pre-printed catalog page to the user's virtual "shopping

cart”. To protect the user’s privacy, however, the unique user ID 60 known to the netpage system is not divulged to applications. This is to prevent different application providers from easily correlating independently accumulated behavioral data.

The netpage registration server instead maintains an anonymous relationship between a user and an application via a unique alias ID 65, as shown in Figure 26. Whenever the user activates a hyperlink tagged with the “registered” attribute, the netpage page server asks the netpage registration server to translate the associated application ID 64, together with the pen ID 61, into an alias ID 65. The alias ID is then submitted to the hyperlink’s application.

10 The application maintains state information indexed by alias ID, and is able to retrieve user-specific state information without knowledge of the global identity of the user.

The system also maintains an independent certificate and private signature key for each of a user's applications, to allow it to sign application transactions on behalf of the user using only application-specific information.

To assist the system in routing product bar code (UPC) “hyperlink” activations, the system records a favorite application on behalf of the user for any number of product types.

Each application is associated with an application provider, and the system
20 maintains an account on behalf of each application provider, to allow it to credit and
debit the provider for click-through fees etc.

An application provider can be a publisher of periodical subscribed content. The system records the user's willingness to receive the subscribed publication, as well as the expected frequency of publication.

25 5 COMMUNICATIONS PROTOCOLS

A communications protocol defines an ordered exchange of messages between entities. In the netpage system, entities such as pens, printers and servers utilise a set of defined protocols to cooperatively handle user interaction with the netpage system.

Each protocol is illustrated by way of a sequence diagram in which the
30 horizontal dimension is used to represent message flow and the vertical dimension is

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The page server then allocates document and page instance IDs and forwards the page descriptions, including page IDs 50, to the printer. It includes the relevant set of multicast channel names for the printer to listen to.

Once the application has distributed all of the document structures to the subscribers' selected printers via the relevant page servers, it multicasts the various subsets of the shared objects on the previously selected multicast channels. Both page servers and printers monitor the appropriate multicast channels and receive their required content objects. They are then able to populate the previously pointcast document structures. This allows the page servers to add complete documents to their databases, and it allows the printers to print the documents.

A preferred embodiment of a hyperlink activation protocol is shown in Figure 44.

When a user clicks on a netpage with a netpage pen, the pen communicates the click to the nearest netpage printer 601. The click identifies the page and a location on the page. The printer already knows the ID 61 of the pen from the pen connection protocol.

The printer determines, via the DNS, the network address of the page server 10a handling the particular page ID 50. The address may already be in its cache if the user has recently interacted with the same page. The printer then forwards the pen ID, its own printer ID 62, the page ID and click location to the page server.

The page server loads the page description 5 identified by the page ID and determines which input element's zone 58, if any, the click lies in. Assuming the relevant input element is a hyperlink element 844, the page server then obtains the associated application ID 64 and link ID 54, and determines, via the DNS, the network address of the application server hosting the application 71.

The page server uses the pen ID 61 to obtain the corresponding user ID 60 from the registration server 11, and then allocates a globally unique hyperlink request ID 52 and builds a hyperlink request 934. The hyperlink request class diagram is shown in Figure 43. The hyperlink request records the IDs of the requesting user and printer, and identifies the clicked hyperlink instance 862. The page server then sends its own server

The application produces a response document according to application-specific logic, and obtains a document ID 51 from an ID server 12. It then sends the document to the page server 10b responsible for the document's newly allocated ID, together with the requesting page server's ID and the hyperlink request ID.

10 The second page server allocates document instance and page IDs 50, returns the newly allocated page IDs to the application, adds the complete document to its own database, and finally sends the page descriptions to the requesting printer.

If the hyperlink requires a user alias, i.e. its “alias required” attribute is set, then the first page server sends both the pen ID 61 and the hyperlink’s application ID 64 to the registration server 11 to obtain not just the user ID corresponding to the pen ID but also the alias ID 65 corresponding to the application ID and the user ID. It includes the alias ID in the message sent to the application, allowing the application to establish a user-specific context for the hyperlink activation.

When a user draws a stroke on a netpage with a netpage pen, the pen
25 communicates the stroke to the nearest netpage printer. The stroke identifies the page
and a path on the page.

The page server loads the page description 5 identified by the page ID and
30 determines which input element's zone 58, if any, the stroke intersects. Assuming the

After a period of inactivity in the zone of the text field, the page server sends the pen ID and the pending strokes to the registration server 11 for interpretation. The registration server identifies the user corresponding to the pen, and uses the user's accumulated handwriting model 822 to interpret the strokes as handwritten text. Once it has converted the strokes to text, the registration server returns the text to the requesting page server. The page server appends the text to the text value of the text field.

10 Assuming the input element whose zone the stroke intersects is a signature field 880, the page server 10 appends the stroke to the signature field's digital ink.

The digital signature includes the alias ID 65 of the corresponding user. This allows a single form to capture multiple users' signatures.

A preferred embodiment of a form submission protocol is shown in Figure 45.

In the case of a form hyperlink, the hyperlink activation message sent by the

5 5.6 COMMISSION PAYMENT PROTOCOL

In an e-commerce environment, fees and commissions may be payable from an application provider to a publisher on click-throughs, transactions and sales.

10 Commissions on fees and commissions on commissions may also be payable from the publisher to the provider of the printer.

15 The target application receives the hyperlink request ID from the page server 10
when the hyperlink is first activated, as described in Section 5.2. When the target
application needs to credit the source application provider, it sends the application
provider credit to the original page server together with the hyperlink request ID. The
page server uses the hyperlink request ID to identify the source application, and sends
20 the credit on to the relevant registration server 11 together with the source application ID
64, its own server ID 53, and the hyperlink request ID. The registration server credits the
corresponding application provider's account 827. It also notifies the application
provider.

If the application provider needs to credit the printer provider, it sends the printer provider credit to the original page server together with the hyperlink request ID. The page server uses the hyperlink request ID to identify the printer, and sends the credit on to the relevant registration server together with the printer ID. The registration server credits the corresponding printer provider account 814.

The source application provider is optionally notified of the identity of the
30 target application provider, and the printer provider of the identity of the source

6 NETPAGE PEN DESCRIPTION

Referring to Figures 8 and 9, the pen, generally designated by reference numeral 101, includes a housing 102 in the form of a plastics moulding having walls 103 defining an interior space 104 for mounting the pen components. The pen top 105 is in operation rotatably mounted at one end 106 of the housing 102. A semi-transparent cover 107 is secured to the opposite end 108 of the housing 102. The cover 107 is also of moulded plastics, and is formed from semi-transparent material in order to enable the user to view the status of the LED mounted within the housing 102. The cover 107 includes a main part 109 which substantially surrounds the end 108 of the housing 102 and a projecting portion 110 which projects back from the main part 109 and fits within a corresponding slot 111 formed in the walls 103 of the housing 102. A radio antenna 112 is mounted behind the projecting portion 110, within the housing 102. Screw threads 113 surrounding an aperture 113A on the cover 107 are arranged to receive a metal end piece 114, including corresponding screw threads 115. The metal end piece 114 is removable to enable ink cartridge replacement.

The pen can operate both as a normal marking ink pen and as a non-marking stylus. An ink pen cartridge 118 with nib 119 and a stylus 120 with stylus nib 121 are mounted side by side within the housing 102. Either the ink cartridge nib 119 or the stylus nib 121 can be brought forward through open end 122 of the metal end piece 114, by rotation of the pen top 105. Respective slider blocks 123 and 124 are mounted to the ink cartridge 118 and stylus 120, respectively. A rotatable cam barrel 125 is secured to the pen top 105 in operation and arranged to rotate therewith. The cam barrel 125 includes a cam 126 in the form of a slot within the walls 181 of the cam barrel. Cam followers 127 and 128 projecting from slider blocks 123 and 124 fit within the cam slot 126. On rotation of the cam barrel 125, the slider blocks 123 or 124 move relative to each other to project either the pen nib 119 or stylus nib 121 out through the hole 122 in

- Stylus 120 nib 121 out;
- Ink cartridge 118 nib 119 out; and

- A second flex PCB 129, is mounted on an electronics chassis 130 which sits within the housing 102. The second flex PCB 129 mounts an infrared LED 131 for providing infrared radiation for projection onto the surface. An image sensor 132 is provided mounted on the second flex PCB 129 for receiving reflected radiation from the surface. The second flex PCB 129 also mounts a radio frequency chip 133, which includes an RF transmitter and RF receiver, and a controller chip 134 for controlling operation of the pen 101. An optics block 135 (formed from moulded clear plastics) sits within the cover 107 and projects an infrared beam onto the surface and receives images onto the image sensor 132. Power supply wires 136 connect the components on the second flex PCB 129 to battery contacts 137 which are mounted within the cam barrel 125. A terminal 138 connects to the battery contacts 137 and the cam barrel 125. A three volt rechargeable battery 139 sits within the cam barrel 125 in contact with the battery contacts. An induction charging coil 140 is mounted about the second flex PCB 129 to enable recharging of the battery 139 via induction. The second flex PCB 129 also mounts an infrared LED 143 and infrared photodiode 144 for detecting displacement in the cam barrel 125 when either the stylus 120 or the ink cartridge 118 is used for writing, in order to enable a determination of the force being applied to the surface by the pen nib 119 or stylus nib 121. The IR photodiode 144 detects light from the IR LED 143 via reflectors (not shown) mounted on the slider blocks 123 and 124.

- ## 6.2 PEN CONTROLLER

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5 imaged tag.

computing system.

10 formed. When the pen 101 moves out of range, digital ink data is buffered within the pen 101 (the pen 101 circuitry includes a buffer arranged to store digital ink data for approximately 12 minutes of the pen motion on the surface) and can be transmitted later.

15 chip 134. Figure 10 also shows representations of the RF chip 133, the image sensor 132, the tri-color status LED 116, the IR illumination LED 131, the IR force sensor LED 143, and the force sensor photodiode 144.

memory 147 and a 512 KB DRAM 148 are also included. An analog-to-digital converter 149 is arranged to convert the analog signal from the force sensor photodiode 144 to a digital signal.

25 the RF chip 133 which includes an RF circuit 155 and RF resonators and inductors 156
connected to the antenna 112.

30 the radio transceiver 153. It is a medium-performance (~40MHz) general-purpose RISC

The processor 145, digital transceiver components (transceiver controller 153 and baseband circuit 154), image sensor interface 152, flash memory 147 and 512KB DRAM 148 are integrated in a single controller ASIC. Analog RF components (RF circuit 155 and RF resonators and inductors 156) are provided in the separate RF chip.

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The provision of the accelerometers enables this embodiment of the pen 101 to sense motion without reference to surface location tags, allowing the location tags to be sampled at a lower rate. Each location tag ID can then identify an object of interest rather than a position on the surface. For example, if the object is a user interface input element (e.g. a command button), then the tag ID of each location tag within the area of the input element can directly identify the input element.

The acceleration measured by the accelerometers in each of the x and y directions is integrated with respect to time to produce an instantaneous velocity and position.

Since the starting position of the stroke is not known, only relative positions
5 within a stroke are calculated. Although position integration accumulates errors in the
sensed acceleration, accelerometers typically have high resolution, and the time duration
of a stroke, over which errors accumulate, is short.

7 NETPAGE PRINTER DESCRIPTION

7.1 PRINTER MECHANICS

10 The vertically-mounted netpage wallprinter 601 is shown fully assembled in Figure 11. It prints netpages on Letter/A4 sized media using duplexed 8½" Memjet™ print engines 602 and 603, as shown in Figures 12 and 12a. It uses a straight paper path with the paper 604 passing through the duplexed print engines 602 and 603 which print both sides of a sheet simultaneously, in full color and with full bleed.

15 An integral binding assembly 605 applies a strip of glue along one edge of each printed sheet, allowing it to adhere to the previous sheet when pressed against it. This creates a final bound document 618 which can range in thickness from one sheet to several hundred sheets.

The replaceable ink cartridge 627, shown in Figure 13 coupled with the
20 duplexed print engines, has bladders or chambers for storing fixative, adhesive, and
cyan, magenta, yellow, black and infrared inks. The cartridge also contains a micro air
filter in a base molding. The micro air filter interfaces with an air pump 638 inside the
printer via a hose 639. This provides filtered air to the printheads to prevent ingress of
micro particles into the Memjet™ printheads 350 which might otherwise clog the
25 printhead nozzles. By incorporating the air filter within the cartridge, the operational life
of the filter is effectively linked to the life of the cartridge. The ink cartridge is a fully
recyclable product with a capacity for printing and gluing 3000 pages (1500 sheets).

Referring to Figure 12, the motorized media pick-up roller assembly 626 pushes the top sheet directly from the media tray past a paper sensor on the first print engine 602 into the duplexed Memjet™ printhead assembly. The two Memjet™ print

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The paper exits the first Memjet™ print engine 602 through a set of powered exit spike wheels (aligned along the straight paper path), which act against a rubberized roller. These spike wheels contact the ‘wet’ printed surface and continue to feed the sheet 604 into the second Memjet™ print engine 603.

Referring to Figures 12 and 12a, the paper 604 passes from the duplexed print engines 602 and 603 into the binder assembly 605. The printed page passes between a powered spike wheel axle 670 with a fibrous support roller and another movable axle with spike wheels and a momentary action glue wheel. The movable axle/glue assembly 673 is mounted to a metal support bracket and it is transported forward to interface with the powered axle 670 via gears by action of a camshaft. A separate motor powers this camshaft.

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7.2 PRINTER CONTROLLER ARCHITECTURE

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controller 753, baseband circuit 754, RF circuit 755, and RF resonators and inductors 756), dual raster image processor (RIP) DSPs 757, duplexed print engine controllers 760a and 760b, flash memory 658, and 64MB of DRAM 657, as illustrated in Figure 14.

5 The controlling processor handles communication with the network 19 and with local wireless netpage pens 101, senses the help button 617, controls the user interface LEDs 613-616, and feeds and synchronizes the RIP DSPs 757 and print engine controllers 760. It consists of a medium-performance general-purpose microprocessor. The controlling processor 750 communicates with the print engine controllers 760 via a high-speed serial bus 659.

10 The RIP DSPs rasterize and compress page descriptions to the netpage printer's compressed page format. Each print engine controller expands, dithers and prints page images to its associated Memjet™ printhead 350 in real time (i.e. at over 30 pages per minute). The duplexed print engine controllers print both sides of a sheet simultaneously.

15 The master print engine controller 760a controls the paper transport and monitors ink usage in conjunction with the master QA chip 665 and the ink cartridge QA chip 761.

The printer controller's flash memory 658 holds the software for both the processor 750 and the DSPs 757, as well as configuration data. This is copied to main memory 657 at boot time.

20 The processor 750, DSPs 757, and digital transceiver components (transceiver controller 753 and baseband circuit 754) are integrated in a single controller ASIC 656. Analog RF components (RF circuit 755 and RF resonators and inductors 756) are provided in a separate RF chip 762. The network interface module 625 is separate, since netpage printers allow the network connection to be factory-selected or field-selected. 25 Flash memory 658 and the 2×256Mbit (64MB) DRAM 657 is also off-chip. The print engine controllers 760 are provided in separate ASICs.

A variety of network interface modules 625 are provided, each providing a netpage network interface 751 and optionally a local computer or network interface 752. Netpage network Internet interfaces include POTS modems, Hybrid Fiber-Coax (HFC) 30 cable modems, ISDN modems, DSL modems, satellite transceivers, current and next-

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The main processor 750 passes back-to-back page images to the duplexed print

5 7.2.2 PRINT ENGINE CONTROLLER

The print engine controller 360 operates in a double buffered manner. While one page is loaded into DRAM 769 via the high speed serial interface 659, the previously loaded page is read from DRAM 769 and passed through the print engine controller pipeline. Once the page has finished printing, the page just loaded is printed while another page is loaded.

25 When several print engine controllers 760 are used in unison, such as in a
duplexed configuration, they are synchronized via a shared line sync signal 770. Only
one print engine 760, selected via the external master/slave pin 771, generates the line
sync signal 770 onto the shared line.

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In the 8½” versions of the netpage printer, the two print engines each prints 30 Letter pages per minute along the long dimension of the page (11”), giving a line rate of 8.8 kHz at 1600 dpi. In the 12” versions of the netpage printer, the two print engines each prints 45 Letter pages per minute along the short dimension of the page (8½”), giving a line rate of 10.2 kHz. These line rates are well within the operating frequency of the Memjet™ printhead, which in the current design exceeds 30 kHz.

The netpage system accommodates a large variety of business implementation procedures for allowing users and providers of the technology to leverage off and to profit from their participation in the netpage system. To best understand the system the following description of the business implementation procedures and equipment should be read in conjunction with the description in the specification of the available hardware and software options, including printers, communication protocols, protocols for payment, determining account balances and the like.

• An online publisher who provides an online publication that is accessible via the netpage network;

20 • One or more online advertisers who wish to place advertising in the online publication;

• A number of users, each of which is accesses the online publication with a printer module. Preferably, the modules are provided by a printer module provider to the users at no cost, or at a cost that is subsidised by the advertisers or the publisher. However, in some cases the user purchases the module at its market value; and

25 • A storage provider who maintains one or more databases which store the information required to allow the system to operate.

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5 It will also be appreciated by those skilled in the art that all the above named roles need not necessarily be performed by different entities. For example, in some cases the storage provider and the publisher are the same entity, while in other cases the printer provider and the publisher are the same entity.

15 Other terms used include "a printer using interactive paper" and "an on-demand printer". This is reference to a printer for interacting with the netpage system to apply the tags and/or interacting with the user to determine which tag the user has designated. A variety of alternative printer configurations are available, some of which have been described in more detail elsewhere in the specification.

8.1 NOTATION

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with an object participant. Each action arrow is labelled with a description of the action. Actions are spatially arranged so that time proceeds from top to bottom and left to right. "Later" actions may coincide with, but never be earlier than, "earlier" actions.

- Any action is understood to be "caused" by the immediately prior action
- 5 which the subject of the action was an object of. In the absence of a prior action, the action is understood to be spontaneous.

Respective reference numerals are used to label certain actions and participants to assist the reader's understanding of the embodiment being described.

10 8.2 COMBINATIONS OF DIFFERENT EMBODIMENTS WITHIN THE SCOPE OF THE INVENTION

- The following preferred embodiments are separately described to facilitate understanding of the invention. However, it will be appreciated that more complex embodiments are obtained through the combination of these different embodiments to achieve advantageous results for specific circumstances. Accordingly, the combination
- 15 of different embodiments to form a hybrid system is intended to fall within the scope of the present invention and the following claims which define that invention.

A preferred embodiment of a commission payment protocol, which provides support for various commission payments described in the following sections, is described in section 5.6 above and illustrated in Figure 46.

20 8.2.1 Netpage Publisher

- In broad terms, this embodiment includes a system for providing a user with a printed publication from a first party who is an online publisher. The system includes a publication source in the form of a computer based storage server for storing publication data representative of the publication. The publication data includes first information
- 25 about a second party who is an advertiser in the online publication. A user printer module, in the form of an on-demand interactive printer, interfaces the user with the publication server and is responsive to the user requesting the printed publication for reproducing the printed publication on a printed medium for viewing by the user. Identifier means, in the form of a printer head and associated hardware and software
- 30 contained within the printer, applies an identifier to the printed medium. Upon

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are manually operated by the user.

In some embodiments, the account server automates the payments and provides the parties to the transactions with all the necessary reporting and summaries to substantiate the quantum of the payments. Preferably, the account server generates a
5 disable signal if the payment calculated as payable by the second party is not made available or paid within a predetermined time, where the generation of the disable signal prevents the module from obtaining the first or the second information which is derived from that second party. That is, an automated debtor system is applied. Preferably, all parties to the transaction have electronic bank accounts that are accessible to the account
10 server for effecting the necessary transactions.

The system also allows the parties, and importantly the second party or the advertiser, to obtain an indication of the success of the advertising by monitoring one or more of the following:

- the number of times that the users designate the second information;
- 15 • the number and/or value of sales that are achieved through the users designating the second information; and
- the cost savings gained through the use of online selling over that of shop front retailing.

Where the second information is a link to a third party, the identifier is related
20 to that second information such that designation by the user of the second information results in designation of the identifier which, in turn, ensures that the third information includes either or both of further information about the goods and/or services being offered for use and/or sale by the third party or instructions as to how the user should proceed to effect that use and/or a purchase of those goods and/or services of the third
25 party. Preferably, the second party obtains an indication of the success of the link by monitoring one or more of: the number or proportion of users selecting the click-through; and the number or proportion of users purchasing or making use of the goods and/or services of the third party.

It will be appreciated that the monitoring allows the parties to accurately
30 estimate the cost/benefit achieved by the advertising and, hence to plan for future

In other embodiments the first information includes advertising derived from a third party and the calculation means determines the quantum of a payment that is made by the third party to the first party. In some cases the advertising is solicited by the user, while in others the advertising is unsolicited.

While in the above embodiments the printed media are generated by the user's printer module, as an alternative, or in addition to this, the printed media are selectively generated at a remote printer and subsequently provided to the user for viewing.

8.2.1.1 Advertising Fees

In some embodiments the publisher automatically delivers the publication to a subscribing user's printer on a periodic basis. For example, in the case of the publisher being an online newspaper, an updated publication is provided to the user's printer each weekday morning at a predetermined time. This time will default to a non-peak processing time for the publisher. However, the user can specify the time, and may be coordinated with the normal rising time of the user.

Preferably, the publication is printed as interactive paper.

As illustrated in Figure 47, this embodiment operates as follows:

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5 • The publisher 41 charges the advertiser 42 an agreed advertising fee, as represented by arrow 503.

For practical purposes, advertising fees are negotiated, invoiced and settled in
10 bulk. In some embodiments the fees are part of a wider advertising agreement.

This embodiment allows a publisher who publishes on interactive paper to receive click-through fees on advertising placed within its publications. This provides a profitable role for a publisher who publishes on interactive paper, and allows the publisher to attract readers by being able to provide them with subsidised or free publications.

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- An advertiser 42 places a hyperlink 505 with a publisher 41.
- The publisher 41 eventually prints the hyperlink, as represented by arrow 506, and typically as part of one of the publisher's publications. The result is one or more printed pages 1 being created that contain the publication, including the hyperlink.

- The advertiser 42 pays the publisher 41 an agreed click-through fee 509.

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8.2.1.3 Sales Commissions

This embodiment allows a publisher who publishes on interactive paper to receive commissions on sales initiated through advertising placed within its publications. This provides a profitable role for a publisher who publishes on interactive paper, and allows the publisher to attract readers by being able to provide them with subsidised or free publications.

As illustrated in Figure 49, where corresponding features are denoted by corresponding reference numerals, this embodiment operates as follows:

- 10 publisher 41.
- The publisher 41 eventually prints the hyperlink, as represented by arrow 511, typically as part of one of the publisher's publications. The result is one or more printed pages 1 being created that contain the publication, including the hyperlink.
 - When a user 40 clicks on the hyperlink to request a linked document from the
15 merchant 43, the merchant is notified.
 - When the user 40 eventually makes an online purchase via the linked document (or via a document obtained via the linked document), the merchant 43 is notified.
 - The merchant 43 pays the publisher 41 an agreed commission on the sale.

20 Preferably, the sales commission is a fixed fee. However, other embodiments make use of a commission that is based on the value of the sale. For practical purposes, sales commissions are negotiated, invoiced and settled in bulk, and are often part of wider advertising agreements.

8.2.2 Netpage Printer Provider

25 In broad terms, this embodiment includes a system for providing to a user printed information obtained from a remote source in the form of the online publication. The system includes a user module in the form of an interactive printer for interfacing the user with the online publication. The module is responsive to the user requesting first information from the publication, which may be the publication itself, for generating a
30 first printed medium that displays to the user the first information together with second

5 Calculation means, in the form of the online publisher's server, is responsive to the module for determining a payment to be made by the advertiser to the printer provider. In practice, the advertiser would pay the online publisher and, in the case where the printer provider was different to the publisher, the publisher would provide a payment to the printer provider.

15 The payment includes, in some embodiments, another component in addition to or as a substitute for the above. For example, where the second information is associated with the second party the payment is a predetermined function of the number of second printed media generated. So, where the second party is an advertiser the payment is increased for successful hits on their specific advertising.

Where the second party is a supplier of goods and/or services, the first information or the second information is usually arranged to allow the user to purchase those goods and/or services at a predetermined purchase price. In turn, the payment is calculated as a predetermined function of the purchase price of the goods and/or services actually purchased by the user.

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second party. In these embodiments the calculation means is responsive to the designation of the identifier for determining the payment. If required, however, the calculation means is responsive only to the designation of the identifier for determining the payment such that the advertiser pays the publisher only for successful links to the advertising information.

Some more specific examples follow and are described with reference to Figures 50 to 52.

8.2.2.1 Commissions on Advertising Fees

In this embodiment the provider of an interactive printer receives a percentage of advertising fees earned directly through the printer. This provides a profitable role for a provider of interactive printers, and allows the provider to attract users by partially or fully subsidising the capital and running costs of each user's printer.

As illustrated in Figure 50, where corresponding features are denoted by corresponding reference numerals, the system is operates as follows:

- A printer provider 72 provides a user with a printer 45. While in this embodiment the provider 72 retains ownership of the printer, in other embodiments that ownership resides with the respective users.
- An advertiser 42 places an advertisement, as represented by arrow 520, with a publisher 41.
- The publisher 41 eventually prints the advertisement on the printer 45, typically as part of one of the publisher's publications. The result is one or more printed pages 1 being created that contain the publication, including the advertisement.
- The publisher 41 charges the advertiser 42 an agreed advertising fee, as represented by arrow 523.
- The advertiser 42 pays the publisher 41 the advertising fee, as represented by arrow 524.
- The publisher 41 pays the printer provider 72 an agreed commission on the advertising fee, as represented by arrow 525.

8.2.2.2 Commissions on Click-Through Fees

In another embodiment, the provider of an interactive printer receives a percentage of click-through fees earned directly through the printer. This provides a profitable role for the provider of interactive printers, and allows the provider to attract users by partially or fully subsidising the capital and running costs of each user's printer.

As illustrated in Figure 51, where corresponding features are denoted by corresponding reference numerals, the system operates as follows:

- The printer provider 72 provides the user 40 with a printer 45.
- An advertiser 42 places a hyperlink with a publisher 41.
- The publisher eventually prints the hyperlink, typically as part of one of the publisher's publications. The result is one or more printed pages 1 being created that contain the publication, including the hyperlink.
- When the user 40 clicks on the hyperlink, as it is represented on the interactive paper, for example to request a linked document from the advertiser 42, the advertiser is notified.
- The advertiser 42 pays the publisher 41 an agreed click-through fee.
- The publisher 41 pays the printer provider 72 an agreed commission on the click-through fee.

8.2.2.3 Commissions on Sales Commissions

This embodiment allows the provider of an interactive printer to receive a percentage of sales commissions earned directly through the printer. This provides a profitable role for the provider of interactive printers, and allows the provider to attract users by partially or fully subsidising the capital and running costs of each user's printer.

As illustrated in Figure 52, where corresponding features are denoted by corresponding reference numerals, this embodiment operates as follows:

- The printer provider 72 provides the user 40 with a printer 45.
- An advertiser in the form of a merchant 43 places a hyperlink with a publisher 41.
- The publisher 41 eventually prints the hyperlink, typically as part of one of

the publisher's publications. The result is one or more printed pages 1 being created that contain the publication, including the hyperlink.

• When the user 40 clicks on the hyperlink to request a linked document from the merchant 43, the merchant is notified. The "click" occurs through use of the
5 interactive paper.

• When the user 40 eventually makes an online purchase via the linked document (or via a document obtained via the linked document), the merchant 43 is notified.

• The merchant 43 pays the publisher 41 an agreed commission on the sale.
10 • The publisher 41 pays the printer provider 72 an agreed commission on the sales commission.

8.2.3 Netpage Storage Provider

As discussed above, the netpage system preferably interfaces with a plurality of users via respective interactive printers. These printers can access information contained
15 on the system, as required, whether this be initiated by the user or another party to the system such as an online publisher.

Preferred embodiments of the invention include a system database that is owned and/or operated by a storage provider. This database includes data indicative of each page that is available to be printed by an interactive printer. This data will be
20 collectively referred to as page descriptions and preferably includes information that allows identification of the page as well as predetermined spatial locations on the page, when printed.. That is, the system includes a number of actual physical pages that are printed, each of which correspond to a virtual page represented by the respective page descriptions. While each printed page should have a page description, there may exist
25 page descriptions that do not have actual physical counterparts. That being, that a user has not requested the printing of a physical page corresponding to that virtual page.

It is preferred that all pages available to be printed by an interactive printer are persistently stored by the storage provider so that any future interaction with the page can be interpreted with reference to the structure and content of the page. Because a printed
30 page can persist, in effect, indefinitely, the corresponding page description may have to

persist indefinitely as well.

By way of example, if a user marks a page provided by the interactive printer, the respective page description is modified to include the marking. This can be stored as a text or graphic object that overlies the original information, or the description could be
5 simple updated. The former is preferred as it will leave an audit trail of changes that are made by the user. In any event, the system allows the user to subsequently request the page to be printed, and for the printer to provide a fresh printed page that displays the markings in addition to the original information.

In this embodiment, the storage provider is paid, by way of a reimbursement for
10 the costs of providing such persistent storage, from a global fund associated with the netpage system. In other embodiments the payment includes a margin over and above that of the costs so that the storage provider makes a profit. In further embodiments the storage provider is paid a periodic service fee from the global fund.

The payments into the global fund can have a variety of sources. For example,
15 these could include one or more of:

- A proportion of fees paid by users of the interactive printers (which potentially utilise the stored page descriptions);
- A proportion of fees related to advertising;
- A proportion of fees related to click-throughs; and
- 20 • A proportion of fees related to sales.

Examples of the derivation of these fees are described in the preceding sections.

This embodiment allows the provision of persistent storage to be decoupled from fee-earning activities in a network of interactive printers. That is, it allows a
25 profitable role for a participant who is purely a provider of persistent storage.

While the role of a persistent storage provider is not explicitly illustrated in the Figures 47 to 52, it will be understood that that role overlies the functions of the other parties and can cooperate in addition to or separately from those other roles that are described.

The present invention has been described with reference to a preferred embodiment and number of specific alternative embodiments. However, it will be appreciated by those skilled in the relevant fields that a number of other embodiments, differing from those specifically described, will also fall within the spirit and scope of the present invention. Accordingly, it will be understood that the invention is not intended to be limited to the specific embodiments described in the present specification, including documents incorporated by cross-reference as appropriate. The scope of the invention is only limited by the attached claims.

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